Composite Intertank

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The development of reusable graphite/epoxy composite primary structures is critical to both expendable and reusable launch vehicle configurations. A composite structure, lighter than a comparable metallic structure, means a lower vehicle cost. Optimization can reduce both the mass of composite structures and the manufacturing cost of large components.

Primary structures include the fuel tank, oxidizer tank, and intertank. MSFC is developing the intertank—the cylindrical structure connecting the fuel and oxidizer tanks—to be compatible with an industry partner's composite fuel tank. The intertank's design addresses the parameters of a reusable structure and is relevant to any of NASA's reusable launch vehicles. A reusable structure must handle all loads in the expected design envelope without any failure during its operational lifetime. Simultaneously, the reusable concept requires minimum mass structures; therefore, the design of the intertank optimizes to a zero-margin structure.

The intertank is an 8-foot-diameter structure[1] developed by MSFC to support testing of a liquid-hydrogen composite propellant tank.[2] A thorough understanding of design criteria, analysis, failure prediction, manufacturing, and test setup all contribute to achieving the best design. Even though the tests involved represent a large aerospace structure, the derived information applies to composite structures in general. The design criteria for the test specimen are derived from the requirements placed on a full-scale reusable launch vehicle intertank. A winged-body configuration (fig. 93) trade study[3] provided the loading conditions. The

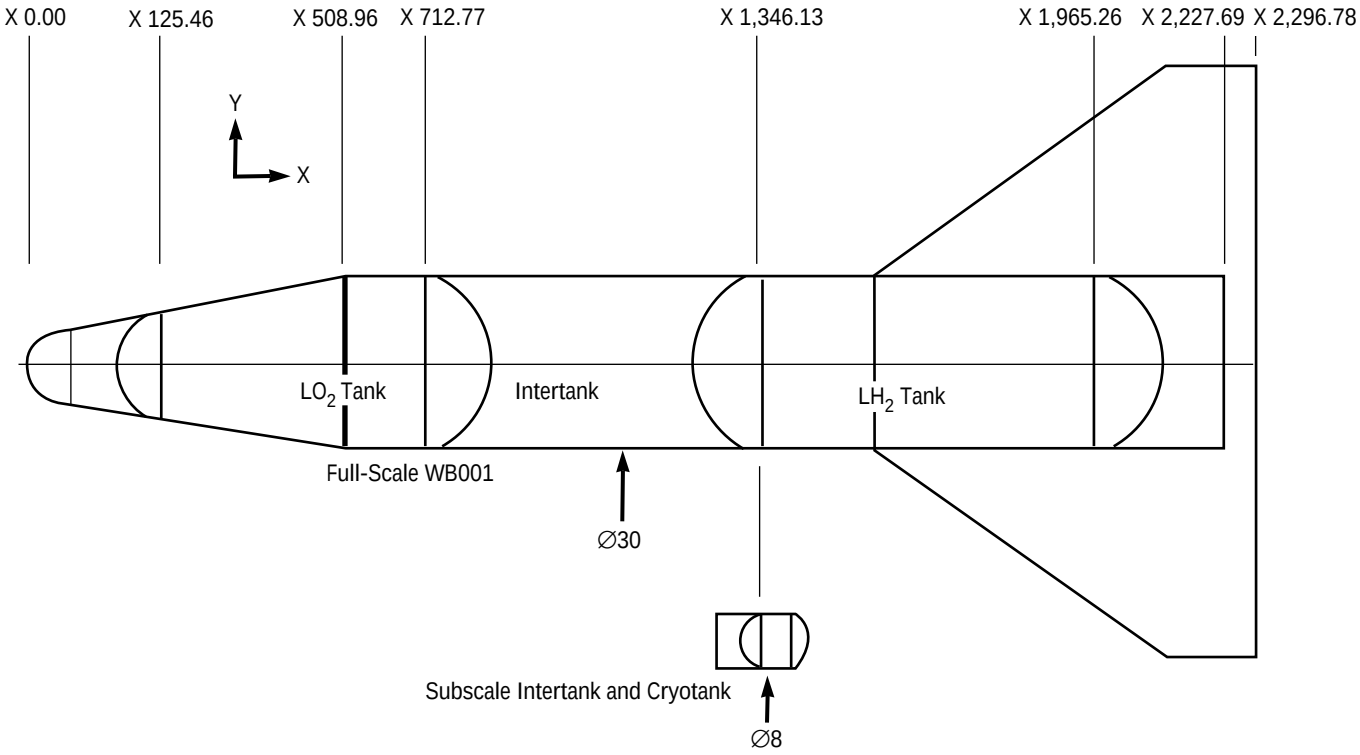

FIGURE 93.—Winged-body configuration reusable launch vehicle.

loads used for a subscale technology demonstration test were to envelop any launch vehicle configuration. Government- and industry-standard design practices determined the appropriate safety, peaking, and distribution factors applied to the load. Material properties were obtained from the manufacturer's data[4] and past projects.[5]

The design covers the aspects of honeycomb sandwich shell construction. Particular focus has been on the interface at each end of the shell. Any advantage in an optimally designed shell can be lost if heavy over-designed end fittings attach the intertank to the propellant tanks. The design has incorporated a genetic algorithm optimization to simultaneously trade both cylindrical shell and end-joint parameters. Shell variables include ply orientation, balance, symmetry, and core thickness, while end-joint variables include joint build-up geometry, edge distance, and bolted interface criteria (bolt mass, diameter, strength). The design alters the variable constituents to meet cylindrical buckling, dimpling, wrinkling, and strength requirements of the shell and to meet local-bearing, net-tension, wedge-splitting, shear-out, and bolt-stress requirements in the end joint.

The technology developed with the composite intertank produces lighter launch vehicles, which enables smaller vehicles with lower operational costs to perform the same functions as older boosters. The technology is also necessary to make advanced launch vehicle concepts feasible. The results of development apply not only to aerospace structures, but can benefit the everyday design of transportation—from airplanes to automobiles.

[1]Composite Primary Structures. NASA Regulation Announcement 8–11.

[2]Composite Cryotank. NASA Regulation Announcement 8–12. Rockwell International.

[3]Winged-Body WB001 Trade Study, MSFC/PD22 WB001 (Liquid-Oxygen Tank Forward) Data Loads. June 5, 1994. CorrectCoord.Excel.

[4]Graphite/Epoxy IM7/8552 System Data. Hercules Aerospace Company.

[5]Lightweight Composite Intertank Structure. March 1993. General Dynamics Space Systems Division, NAS8–37138 MSFC ALS–NLS ADP 3102.

Sponsor: NASA Regulation Announcement 8–11, NASA Regulation Announcement 8–12

Industry Involvement: Rockwell International